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(54) Method for detecting partial discharge in an insulation of an electric power cable

Verfahren zur Feststellung von Teilentladungen in der Isolation eines elektrischen Starkstromkabels

Procédé pour détecter des décharges partielles dans une isolation d'un câblé électrique de puissance

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(56) References cited:

EP-A- 0 147 822	EP-A- 0 182 488
WO-A-88/01748	DE-A- 3 610 170
DE-A- 3 802 841	US-A- 4 064 454
US-A- 4 134 061	US-A- 4 789 829

- PATENT ABSTRACTS OF JAPAN, vol. 11, no. 181 (P-585), 9th July 1985; & JP-A-62 011 177 (HITACHI) 20-01-1987
- PATENT ABSTRACTS OF JAPAN, vol. 7, no. 35 (P-175)[1180], 10th February 1983; & JP-A-57 189 074 (SHOWA DENSEN DENRAN) 20-11-1982
- PATENT ABSTRACTS OF JAPAN, vol. 6, no. 41 (P-106)[919], 13th March 1982; & JP-A-56 157 873 (HITACHI) 05-12-1981
- I.S.A. TRANSACTIONS, vol. 21, no. 4, 1982, pages 37-44, ISA 1982, Research Triangle Park, NC. US; A.L. LANCE et al.: "Phase noise measurement systems"

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Description

FIELD OF THE INVENTION

This invention relates to a method for detecting partial discharge in an insulation of an electric power cable to diagnose the deterioration of the insulation.

BACKGROUND OF THE INVENTION

An electric power cable system comprises a plurality of electric power cables which are connected to provide power cable lines by normal joints, insulating joints, etc., wherein the power cable lines are connected through terminal joints at both ends to high voltage conductors. Each of the power cables comprises, for instance, an electric conductor, an inner semi-conductive layer provided around the electric conductor, an insulation provided around the semi-conductive layer to insulate the electric conductor, an outer semi-conductive layer provided around the insulation, a metal sheath provided around the outer semi-conductive layer, and an anti-corrosion layer of poly-vinyl chrolide provided around the metal sheath. In this power cable system, the metal sheath is connected, typically, at the normal joints, the terminal joints, etc. to the ground by lead wires.

In detecting partial discharge in the insulation of the power cable, a high voltage applied to the power cable system is turned off to stop operation thereof, and a detecting impedance is inserted into a selected one of the lead wires connecting the metal sheaths to the ground. Furthermore, an apparatus for detecting the partial discharge is connected to both terminals of the detecting impedance. Then, a predetermined high voltage is applied to the electric conductor of the power cable, so that the partial discharge occurs at deteriorating or defect portions of the insulation, thereby generating a high frequency pulse therein. This high frequency pulse induces a high frequency current flowing through the lead wire, so that an electric potential difference is generated across the both terminals of the detecting impedance. The electric potential difference is detected in the partial discharge detecting apparatus to diagnose the deterioration of the insulation.

In the other method for detecting the partial discharge in the insulation of the power cable, the detecting impedance is inserted between a coupling capacitor, which is connected to the high voltage conductor connected through the terminal joint to the electric conductor of the power cable, and the ground, and the apparatus for detecting the partial discharge is connected to the both terminals of the detecting impedance. The partial discharge is detected in the same manner as described in the former method.

However, the conventional method for detecting partial discharge in an insulation of an electric power cable has a first disadvantage in that the reliance of the electric power cable system is lowered, because the selected lead wire is removed to insert the detecting impedance between the metal sheath and the ground, and an original state is restored, after the partial discharge detecting procedure is over. Furthermore, second and third disadvantages are observed in that operation of the power cable system is interrupted as described before, and in that the detecting operation is troublesome, because the insertion of the coupling capacitor is inevitable. In addition, there is a fourth disadvantage in that the high frequency pulse is attenuated to be propagated to the coupling capacitor in the latter method, and the coupling capacitor must withstand a high voltage. More additionally, fifth to seventh disadvantages are found in that a high detecting sensitivity of the high frequency pulse is not obtained, because the power cable is exposed to external noise, and an overall capacitance of the power cable is large, in that a S/N ratio is lowered, where a measuring frequency is coincident with a frequency at which a noise level is high, and in that a calibration of the apparatus for detecting the partial discharge is difficult in operation, where the partial discharge is detected at the normal joints, the insulating joints, the cable insulation, etc. which are remote from the terminal joints, because a calibration pulse is applied to the high voltage conductor connected to the electric conductor of the power cable.

The document EP-A 0 182 488 relates to a method for remotely measuring the installation state of a communication cable buried underground. In more detail, pressure, temperature and humidity in a cable and a cable joint case are detected. A capacitor and an inductor composing a resonance circuit is used for a sensor. Information from the resonance circuit placed in the cable joint case is remotely detected by a transmitting and receiving apparatus.

In the document JP-A 62-011177, a calibration pulse is injected across a high voltage conductor and a cable sheath for the calibration. In general, a calibration pulse generator cannot withstand a high voltage, so that the sensitivity is not calibrated at a live state.

It is therefore the object of the present invention to provide a method of calibrating a partial discharge pulse having a small level.

This object is achieved by a method according to claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

The Figs 1A to 1C are explanatory diagrams showing conventional methods for detecting partial discharge in an insulation of an electric apparatus,

Figs. 2A and 2B are an explanatory diagram and an equivalent circuit for calibrating operation in a conventional method for detecting partial discharge in an insulation of an electric apparatus,

Figs. 3A to 3C are a frequency spectrum of noise obtained from an electric power cable,

Figs. 4 to 7 show methods for detecting partial dis-

charge in an insulation of an electric power cable in first to fourth preferred embodiments according to the invention,

Figs. 8 and 9 are an explanatory view, and a circuitry diagram for carrying out calibrating operation in a method for detecting partial discharge in an insulation of an electric power cable,

Figs. 10A and 10B are equivalent circuits for explaining calibrating operation in the invention and the prior art,

Figs. 11 to 13 are an explanatory view, a circuitry diagram, and an equivalent circuit for calibrating operation in a method for detecting partial discharge in an insulation of an electric apparatus in a sixth preferred embodiment according to the invention,

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before explaining a method for detecting partial discharge an insulation of an electric power apparatus in a preferred embodiment according to the invention, the aforementioned conventional methods for detecting partial discharge will be explained.

Figs. 1A to 1C show an electric power cable line, to which the conventional methods for detecting partial discharge in an insulation of a power cable, comprising power cables 1 which are connected to each other by a normal joint 2, and each of which is connected to a high voltage conductor 4 by a terminal joint 3 are applied. Metal sheaths (not shown) of the power cables 1 are connected at the normal joint 2 and the terminal joint 3 to the ground by lead wires 5 and 6, respectively.

In Fig. 1A, a detecting impedance 9 is inserted between the metal sheath and the ground by use of the lead wire 6 connected to the terminal joint 3, and an apparatus 10 for detecting partial discharge is connected to both terminals of the detecting impedance 9. In addition, a coupling capacitor 8 is connected between the high voltage conductor 4 and the ground, thereby providing a closed circuit for the partial discharge detection.

In Fig. 1B, a coupling capacitor 8 is provided be connected at one electrode to the high voltage conductor 4 and at the other electrode to the detecting impedance 9, and a choke coil 7 is provided to stop a high frequency pulse to be passed therethrough and allow the high frequency pulse to be passed through the coupling capacitor 8. As a matter of course, the partial discharge detecting apparatus 10 is connected to the both terminals of the detecting impedance.

In Fig. 1C, the detecting impedance 9 is inserted between the metal sheath and the ground by use of the lead wire 5 connected to the normal joint 2, and is connected at the both terminals to the partial discharge detecting apparatus 10.

In operation, a predetermined high voltage is applied to the high voltage conductor 4. Where partial discharge occurs in the insulation of the power cable 1, especially at the normal and terminal joints 5 and 3, a high frequency pulse is induced between the electric conductor and the metal sheath, so that an electric potential difference is generated across the both terminals of the detecting impedance 9 in accordance with the flowing of a high frequency current through the detecting impedance 9 from the metal sheath to the ground. The electric potential difference is detected by the apparatus 10, so that the deterioration of the insulation is diagnosed in the apparatus 10.

Next, the calibration of the partial discharge detecting apparatus 10 will be explained in Fig. 2A, wherein like parts are indicated by like reference numerals as used in Fig. 1C, except that a calibration signal generator 11 is connected to the high voltage conductor 4 and the metal sheath of the terminal joint 3, and a coupling capacitor 8 of a capacitance C_K is connected between the high voltage conductor 4 and the ground.

Fig. 2B shows an equivalent circuit corresponding to the construction of Fig. 2A. In Fig. 2B, the calibration signal generator 11 supplies a high frequency pulse having a voltage V_Q through a capacitor of a capacitance C_Q across the conductor 12 and the metal sheath 14 of the power cable 1, between which a capacitor 13 of a capacitance C_C is formed. Thus, the high frequency pulse flowing through the capacitor 13 is partially shunted into the detecting impedance 9, so that an electric potential difference is generated across both terminals of the detecting impedance 9. Then, the sensitivity calibration of the partial discharge detecting apparatus 10 is carried out.

Here, if it is assumed that an apparent charge of discharge which is carried out by the capacitor 13 is Q, and an electric potential difference across the capacitor 13 is V_1, the equation (1) obtained

$$Q = V_Q \cdot C_Q = V_1 \cdot C_C \qquad (1)$$

From the equation (1), the equation (2) is obtained.

$$V_1 = \frac{C_Q}{C_C} \cdot V_Q \qquad (2)$$

In an actual power cable system, a length of a power cable line is, for instance, several Km, so that the capacitance C_C is much greater than the capacitance C_Q ($C_C > C_Q$). Consequently, the voltage V_1 becomes very small, so that the calibration of the partial discharge detecting apparatus 10 is difficult in operation to be carried out. In other words, the high frequency pulse V_Q is attenuated to reach the normal joint 2, at which the partial discharge detecting apparatus 10 is located to be connected across the detecting impedance 9.

In the explanation of the methods for detecting partial discharge in the insulation of the power cable system, frequency dependency of noise which has been confirmed by the inventors will be finally explained.

In the detection of the noise frequency dependency, the method as shown in Fig. 1B is used, wherein a length

of the power cables 1 is 10 Km, and the partial discharge detecting apparatus 10 is of a frequency-sweep type signal intensity detector.

Figs. 3A to 3C show a frequency spectrum of noise which is received by the apparatus 10, where no voltage is applied to the conductors of the power cables 1. As clearly illustrated, Fig. 3A shows the frequency spectrum ranging up to 10 MHz which is characterized by having a high level of noise in the vicinity of 4 MHz, and Figs. 3B and 3C show enlarged frequency spectrums which cover ranges of 3 to 5 MHz and 3.8 to 4.2 MHz, respectively. As shown, especially, in Fig. 3C, noise is high in its level at 3.82 MHz, and 3.92 to 3.95 MHz, and low at 3.88 MHz, and 4.0 to 4.14 MHz. It should be noted that the noise level is lower at 3.88 MHz than at 3.82 MHz by approximately 35 dB.

The inventors have confirmed that partial discharge according in an insulation of an electric power cable is also of a frequency spectrum similar to that as described above, because:

(1) a circuit structure of an electric power cable system is complicated to have a number of inductance and capacitance components, by which resonance and anti-resonance are generated at various frequencies, so that an amplitude of a signal is complicatedly varied dependent on a frequency of the signal; and

(2) a high frequency pulse is reflected to go forward and back along an electric power cable line in accordance with the mismatching of impedance, thereby generating a standing wave, so that a high detecting sensitivity is obtained, where a peak point of the standing wave is positioned at a detecting location, while a low detecting sensitivity is obtained, where a nodal point of the standing wave is positioned at the detecting location.

Now, a method for detecting partial discharge in an insulation of an electric power cable in a first preferred embodiment according to the invention will be explained.

In Fig. 4, an electric power cable 1 comprises a copper electric conductor 91, an inner semi-conductive layer 92 including conductive carbon, a cross-linked polyethylene insulation 93, an outer semi-conductive layer 94 including conductive carbon, and an aluminum metal sheath 95. In the power cable 1, the metal sheath 95 is partially removed as indicated by reference numerals 97, thereby providing an isolated metal sheath 96 functioning as a detecting electrode. As a result, a detecting capacitor is formed by the isolated sheath 96 and the conductor 91 sandwiching the insulation 93 therebetween. The detecting impedance 9 is connected at one terminal to the isolated sheath 96, and at the other terminal to the metal sheath 95 by jumper wire 98, and the partial discharge detecting apparatus 10 is connected to the both terminals of the detecting impedance 9.

In operation, it is assumed that partial discharge occurs in the insulation 93 between the isolated sheath 96 and a corresponding region of the conductor 91. Thus, a partial discharge signal which is a high frequency signal flows through the detecting impedance 9, so that the high frequency signal is detected in the partial discharge detecting apparatus 10 in accordance with a voltage generated across the detecting impedance 9.

Fig. 5 shows a method for detecting partial discharge in an insulation of an electric power cable in a second preferred embodiment according to the invention, wherein like parts are indicated by like reference numerals as used in Fig. 5, except that the two detecting impedances 9a and 9b are provided at the sheath removed portions 9a and 9b to be connected across the sheath 95 and the isolated sheath 96, respectively, and the two partial discharge detecting apparatus 10a and 10b are provided to receive voltages generated across the detecting impedances 9a and 9b, respectively.

In the second preferred embodiment, partial discharge can be precisely detected, even if the two sheath removed portions 97 are relatively remote from each other to result in a long isolated sheath 96, because a partial discharge signal is received by any one of the partial discharge detecting apparatus 10a and 10b, before the partial discharge signal is attenuated.

Fig. 6 shows a method for detecting partial discharge in an insulation of an electric power cable in a third preferred embodiment according to the invention, wherein like parts are indicated by like reference numerals as used in Fig. 4, except that the detecting impedance 9 and the partial discharge detecting apparatus 10 are connected across the metal sheath 95 separated at the insulating joint 20 including a connecting sleeve 99 for connecting the conductors 91 and an auxiliary electrode 100 provided on a poly-vinyl chloride sheath 101 covering the metal sheath 95. At the insulating joint 20, generally, a high voltage happens to be applied to the metal sheath 95, where an accident such as ground fault, etc. occurs in the power cable line. Even if such a high voltage is generated thereon, a high voltage proof capacitor is formed between the auxiliary electrode 100 and one of the separated sheaths 95, so that the partial discharge can be detected at the insulating joint 20.

Fig. 7 shows a method for detecting partial discharge in an insulation of an electric power cable, wherein like parts are indicated by like reference numerals as used in Figs. 4 to 6, except that a gapless arrester 102 is connected between the metal sheath 95 in the vicinity of the sheath removed portion 98 and the detecting impedance 9a, and a coupling capacitor 103 is connected between the metal sheath 95 and the detecting impedance 9b. The gapless arrester 102 protects the detecting impedance 9a and the partial discharge detecting apparatus 10a from a surge voltage, and provides a coupling capacitance in the partial discharge detecting system. The separated metal sheath 95 functions as an auxiliary electrode.

Fig. 8 shows a method for detecting partial dis-

charge in an insulation of an electric power cable which comprises a calibration signal generator 11 connected to terminals 95B of metal sheath members 95A insulated by an insulating barrel member 43 and connected to metal sheaths 95 of power cables 1, along with a detecting impedance 9, and a partial discharge detecting apparatus 10 connected to the detecting impedance 9.

Fig. 9 shows a circuitry structure in the fifth preferred embodiment, in which conductors 91 of the power cables 1 are connected by a connecting sleeve 99, and capacitors C_1 and C_2 are formed between the conductors 91 and the metal sheaths 95 insulated by the insulating barrel member 43.

Fig. 10A shows an equivalent circuit corresponding to the circuitry structure in the fifth preferred embodiment, wherein like parts are indicated by like reference numerals as used in Fig. 9.

In this equivalent circuit, it is assumed that the capacitances C_1 and C_2 are equal to each other, a value Z of the detecting impedance 9 is much greater than an impedance Z_{C1} based on the capacitance

$$C_1 \ (Z \gg Z_{C1} = \frac{1}{2\pi f C_1})$$

and the capacitance C_1 is much greater than a capacitance C_Q of of the calibration signal generator 11 ($C_1 \gg C_Q$).

Thus, a voltage V_2 applied across both terminals of the detecting impedance 9 is obtained in the below equation (3).

$$V_2 = \frac{2C_Q}{C_1} V_Q \qquad (3)$$

Here, C_Q, C_1, C_2 and V_Q are known or can be detected.

Comparing the aforementioned equation (2) and the present equation (3), the below equation (4) is obtained.

$$V_2 = 2V_1 \qquad (4)$$

provided that it is assumed that C_C is C_1.

As understood from the equation (4), a high frequency pulse can be detected by a level which is two times as compared to the conventional method. Furthermore, the attenuation caused by the propagation of the high frequency pulse through a long power cable line can be negligible.

Where partial discharge occurs on the side of the capacitor C_1, the equivalent circuit of Fig. 10A is converted to that of Fig. 10B.

In the fifth preferred embodiment, it is assumed that C_1 is C_2, and Z is much greater than Z_{C1} as explained before. Even if these conditions are not met, however, the calibration can correctly be realized by calculating a correcting term in accordance with the fundamental equation.

Fig. 11 shows a method for detecting partial discharge in an insulation of an electric power cable in a sixth preferred embodiment, wherein like parts are indicated by like reference numerals as used in Fig. 8, except that a first pair of detecting electrodes 110 and a second pair of calibrating electrodes 120 are provided on the poly-vinyl chloride sheath 101 of the insulating joint 20 having the insulating barrel member 43 to be connected to the detecting impedance 9 and the calibration signal generator 11, respectively.

Fig. 12 shows a circuitry structure in the sixth preferred embodiment, which is similar to that of Fig. 9.

Fig. 13 shows an equivalent circuit corresponding to the circuitry structure of Fig. 12, wherein like parts are indicated by like reference numerals as used in Fig. 10A, except that capacitances C_{d1} and C_{d2} of capacitors formed by the detecting electrodes 110 and capacitances C_{p1} and C_{p2} of capacitors formed by the detecting electrodes 120 are added to the circuit.

Here, the capacitances C_{p1} and C_{p2} are much greater than the capacitance C_Q (C_{p1}, $C_{p2} \gg C_Q$), respectively, and the detecting impedance Z is much greater than impedances Z_{cd1} and Z_{cd2}

$$(Z \gg Z_{cd1} = \frac{1}{2\pi f C_{d1}}, Z_{cd2} = \frac{1}{2\pi f C_{d2}}),$$

so that the equivalent circuit of Fig. 13 is simplified in the form of the equivalent circuit of Fig. 10B.

Practically, the capacitance C_Q is approximately 10 to 50 pF, so that the detecting electrodes 120 for the calibration signal generator 11 are determined in size to provide a capacitance value of approximately 500 to 1000 pF, thereby resulting in the relation (C_{p1}, $C_{p2} \gg C_Q$). The same is applied to the relation ($Z \gg Z_{cd1}$, Z_{cd2}).

Although the invention has been described with respect to specific embodiment for complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modification and alternative constructions that may occur to one skilled in the art which fairly fall within the basic teaching herein set forth.

Claims

1. Method for detecting partial discharge in an insulation of an electric power cable, said electric power cable having a metal sheath as conductive member, characterized by the steps :

   - separating conductive member sections, on which a high frequency pulse is induced by said partial discharge,

   - detecting said partial discharge by connecting a detecting impedance (9) between said separated conductive member sections; said detecting impedance (9) being connected to a partial discharge detecting apparatus (10), in which said partial discharge is detected to diagnose a

degradation of said insulation, and

- connecting a calibration pulse generator in parallel with said detecting impedance (9) to calibrate said partial discharge detecting apparatus (10).

2. Method as claimed in claim 1, characterized in that said separated conductive member sections are metal sheaths (95, 96) separated in an insulation joint (20) of said electric power cable (1).

3. Method as claimed in claim 2, characterized by a pair of detecting electrodes provided on a plastic anti-corrosion layer covering said separated metal sheaths (95, 96) and connected to said detecting impedance (9).

4. Method as claimed in claim 3, characterized by a pair of calibrating electrodes provided on said plastic anti-corrosion layer to be adjacent to said pair of said detecting electrodes, and connected to said calibration pulse generator.

Patentansprüche

1. Verfahren zum Feststellen von Teilentladungen in der Isolierung eines elektrischen Starkstromkabels, wobei das elektrische Starkstromkabel eine metallische Hülle als leitendes Element hat, gekennzeichnet durch die Schritte:

- Trennen von Abschnitten des leitenden Elements, auf denen ein Hochfrequenzpuls durch die Teilentladung induziert wird,

- Feststellen der Teilentladung durch Schalten einer Erfassungsimpedanz (9) zwischen die getrennten Abschnitte des leitenden Elements; wobei die Erfassungsimpedanz (9) mit einer Feststellungsvorrichtung (10) für Teilentladungen verbunden ist, in der die Teilentladung erfaßt wird, um eine Verschlechterung der Isolation zu diagnostizieren, und

- Schalten eines Kalibrierpulsgenerators parallel zu der Erfassungsimpedanz (9), um die Feststellungsvorrichtung (10) für Teilentladungen zu kalibrieren.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die getrennten Abschnitte des leitenden Elementes metallische Hüllen (95, 96) sind, die in einer Isolationsverbindung (20) des elektrischen Starkstromkabels (1) getrennt sind.

3. Verfahren nach Anspruch 2, gekennzeichnet durch ein Paar Erfassungseleketroden, die auf einer Antikorrosionsschicht aus Kunststoff vorgesehen sind, welche die getrennten metallischen Hüllen (95, 96) überdeckt, und die mit der Erfassungsimpedanz (9) verbunden sind.

4. Verfahren nach Anspruch 3, gekennzeichnet durch ein Paar Kalibrierelektroden, die auf der Antikorrosionsschicht aus Kunststoff so vorgesehen sind, daß sie benachbart dem Paar Erfassungselektroden liegen, und die mit dem Kalibrierpulsgenerator verbunden sind.

Revendications

1. Procédé pour mesurer une décharge partielle dans une isolation d'un câble d'alimentation électrique, ledit câble d'alimentation électrique ayant une gaine métallique servant d'organe conducteur, caractérisé par les étapes de:

- séparation de sections d'organe conducteur, sur lesquelles une impulsion à haute fréquence est induite par ladite décharge partielle,
- mesure de ladite décharge partielle en connectant une impédance de mesure (9) entre lesdites sections séparées d'organes conducteurs ; ladite impédance de mesure (9) étant connectée à un dispositif de mesure de décharge partielle (10), dans lequel ladite décharge partielle est mesurée pour diagnostiquer une altération de ladite isolation, et
- connexion d'un générateur d'impulsion d'étalonnage en parallèle avec ladite impédance de mesure (9), pour étalonner ledit appareil de mesure de décharge partielle (10).

2. Procédé selon la revendication 1, caractérisé en ce que lesdites sections séparées d'organes conducteurs sont des gaines métalliques (95, 96) séparées par une jonction d'isolation (20) dudit câble d'alimentation électrique (1).

3. Procédé selon la revendication 2, caractérisé par un couple d'électrodes de mesure prévu sur une couche anticorrosion en matière plastique, recouvrant lesdites gaines métalliques (95, 96) séparées et connectées à ladite impédance de mesure (9).

4. Procédé selon la revendication 3, caractérisé par un couple d'électrodes d'étalonnage prévu sur ladite couche anticorrosion en matière plastique de manière à être adjacent audit couple desdites électrodes de mesure et connecté audit générateur d'impulsion d'étalonnage.

FIG. 1A PRIOR ART

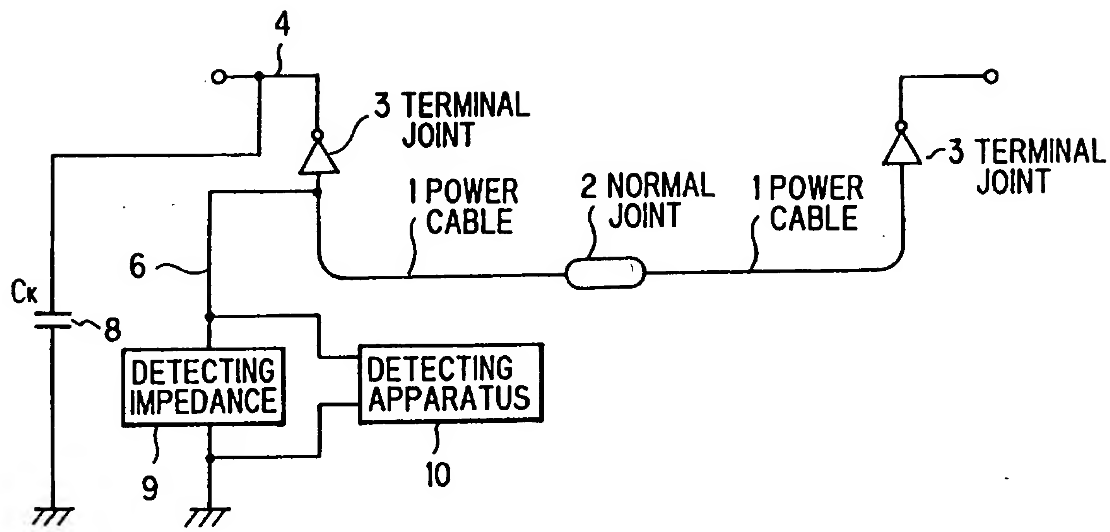


FIG. 1B PRIOR ART

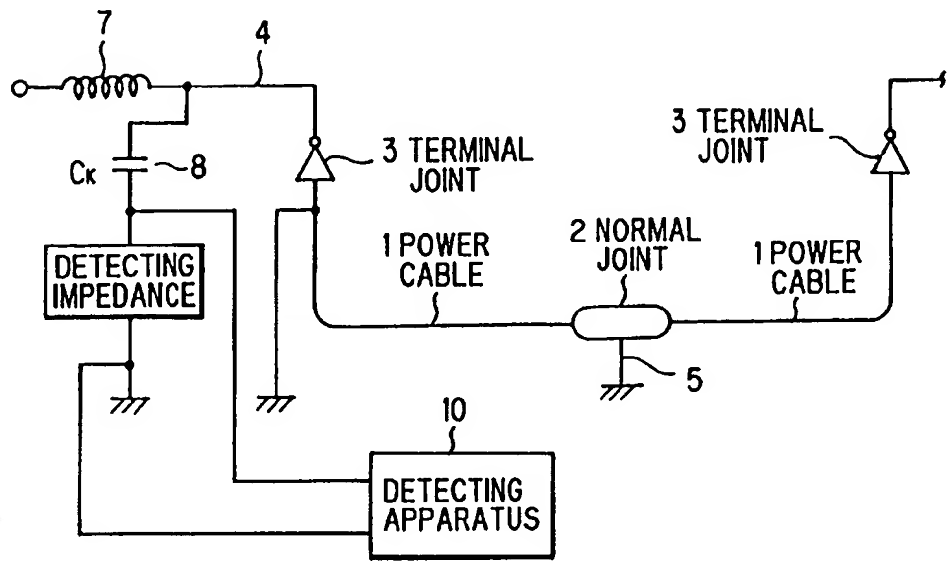


FIG. 1C PRIOR ART

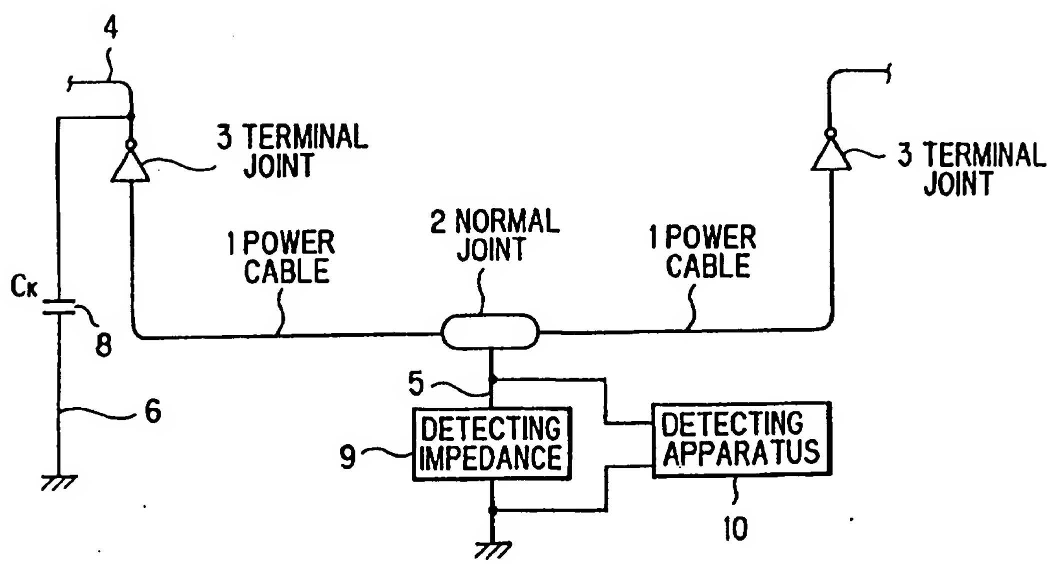


FIG.2A PRIOR ART

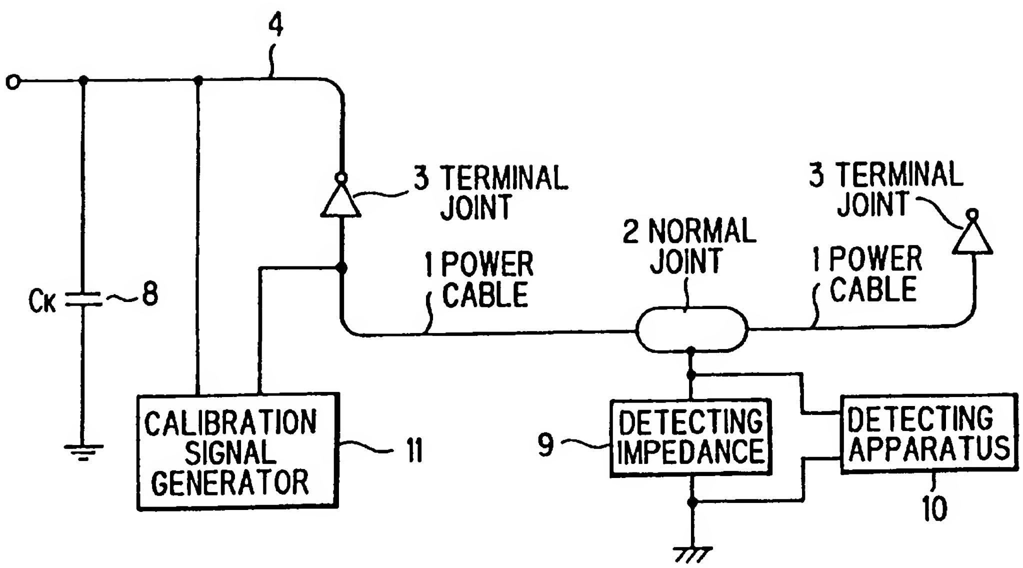


FIG.2B PRIOR ART

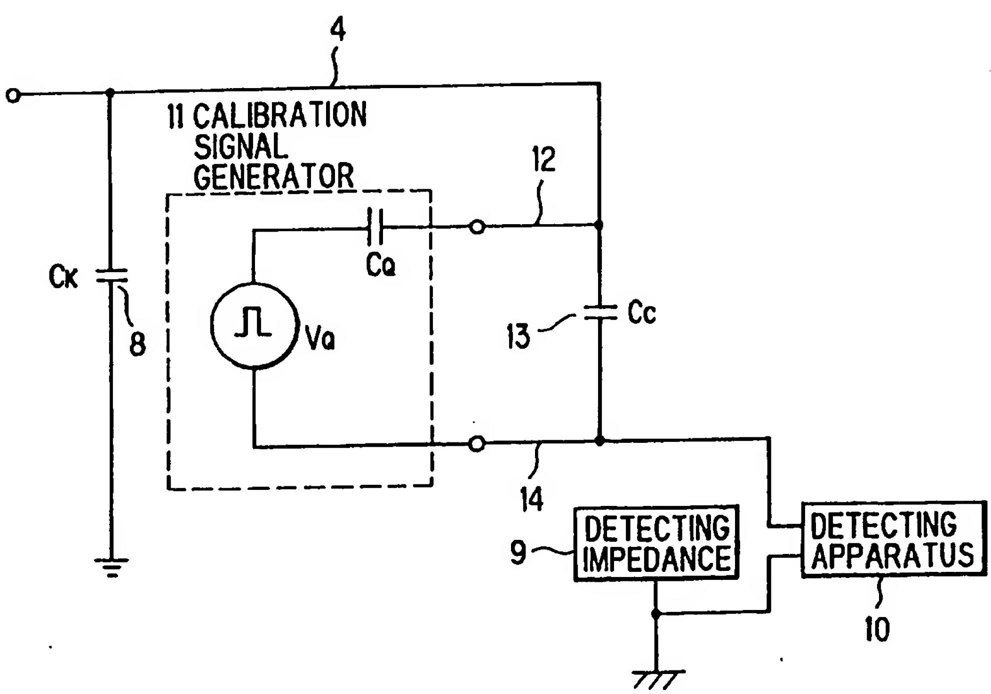


FIG. 3A

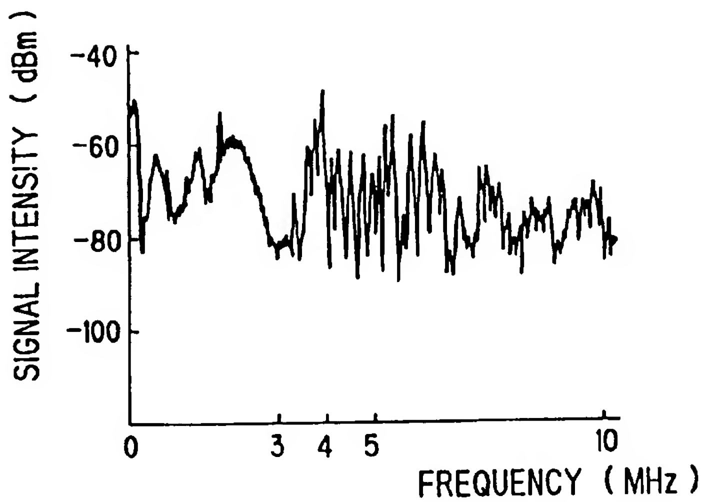


FIG. 3B

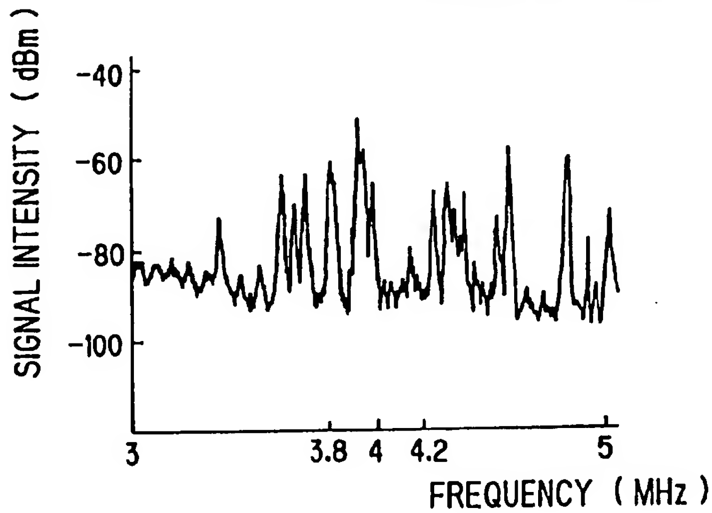


FIG. 3C

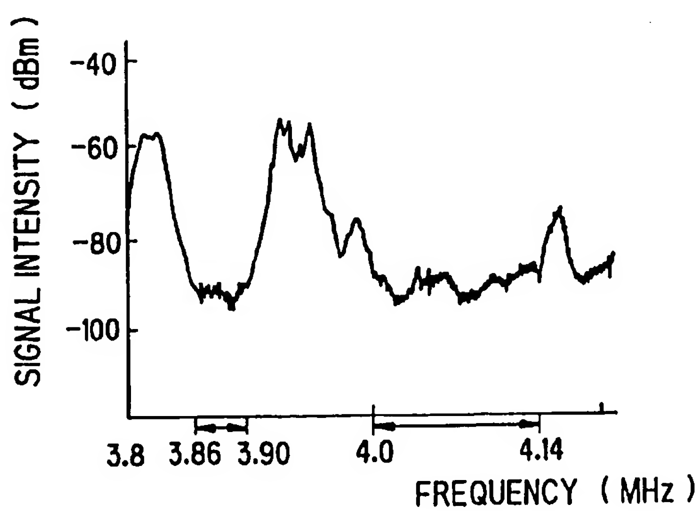
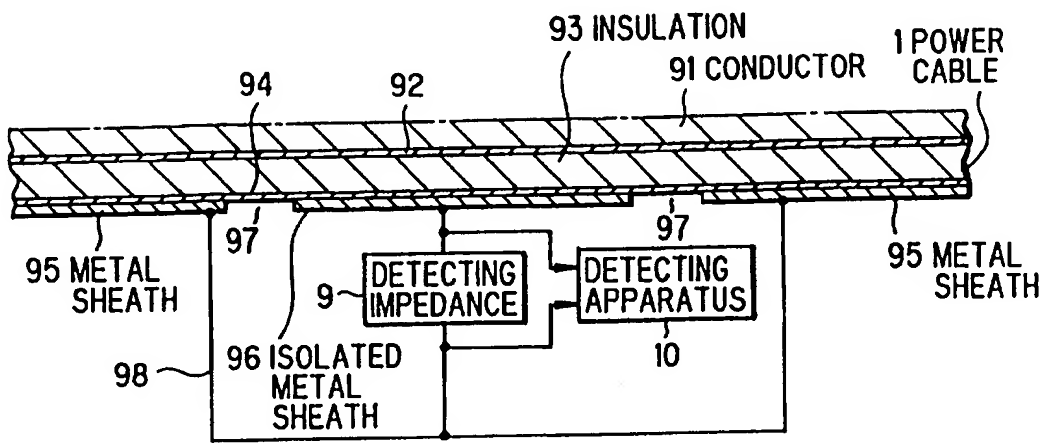


FIG. 4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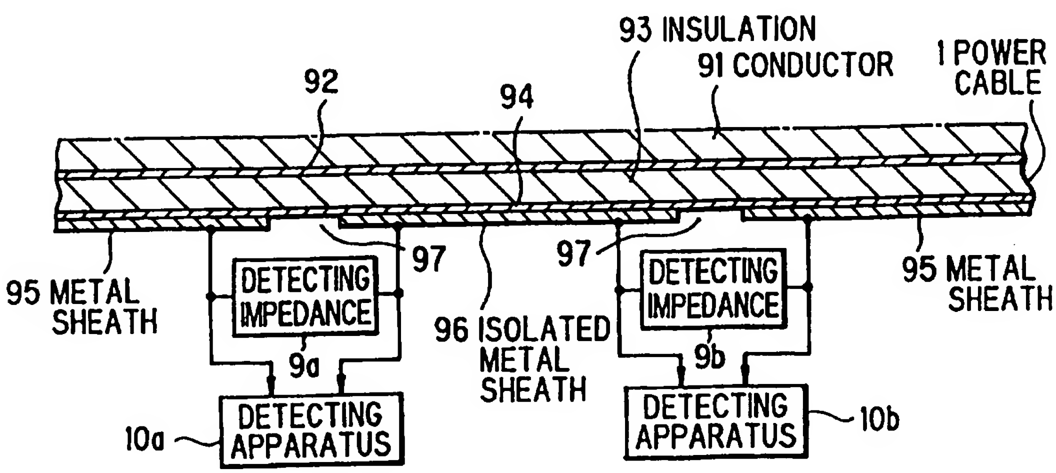
91 CONDUCTOR
1 POWER CABLE
94
92
97
97
95 METAL SHEATH
95 METAL SHEATH
9
DETECTING IMPEDANCE
DETECTING APPARATUS
10
98
96 ISOLATED METAL SHEATH

FIG. 5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95 METAL SHEATH
DETECTING IMPEDANCE
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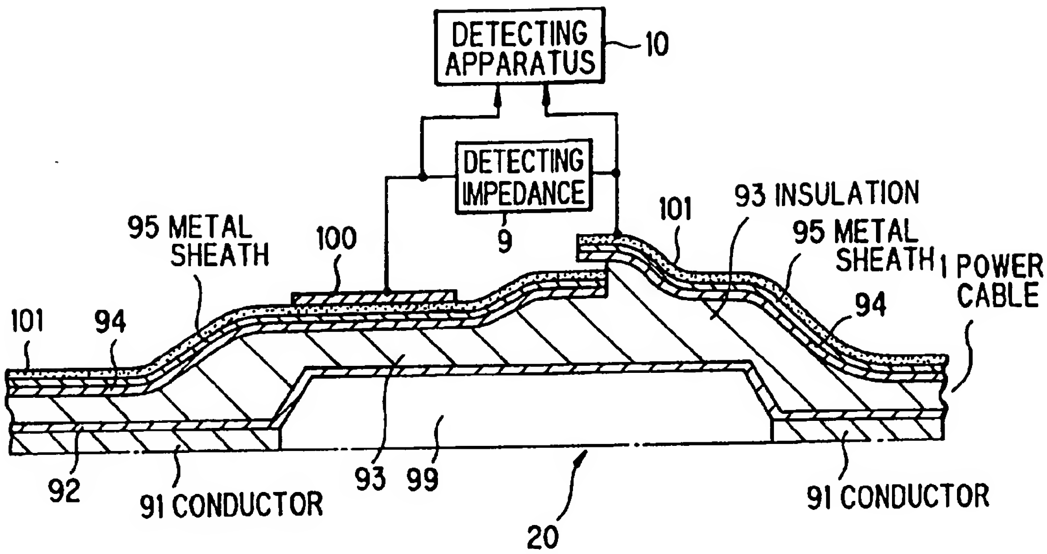
DETECTING APPARATUS
DETECTING APPARATUS
10a
10b

FIG. 6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10
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9
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100
101
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94
94
92
91 CONDUCTOR
93
99
20
91 CONDUCTOR

FIG. 7

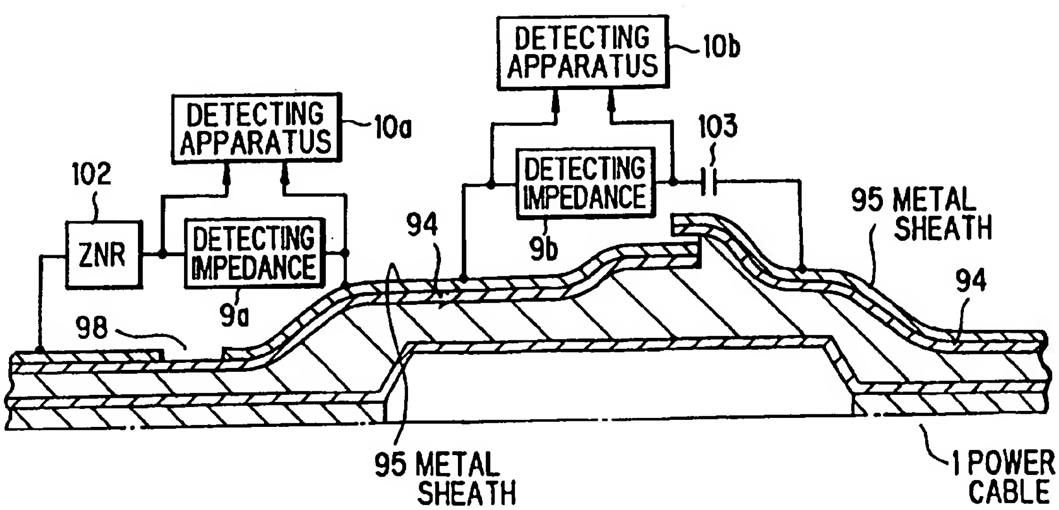

DETECTING APPARATUS
10b
DETECTING APPARATUS
10a
103
102
ZNR
DETECTING IMPEDANCE
9a
DETECTING IMPEDANCE
9b
94
95 METAL SHEATH
94
98
95 METAL SHEATH
1 POWER CABLE

FIG. 8

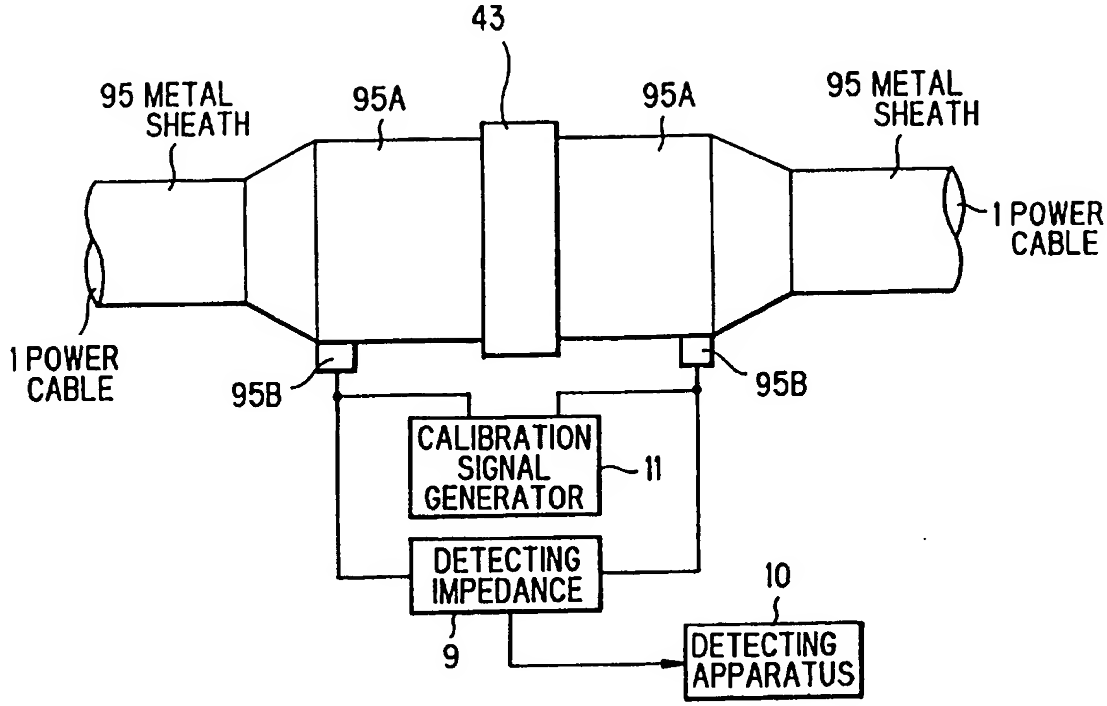

43
95 METAL SHEATH
95A
95A
95 METAL SHEATH
1 POWER CABLE
1 POWER CABLE
95B
95B
CALIBRATION SIGNAL GENERATOR
11
DETECTING IMPEDANCE
9
10
DETECTING APPARATUS

FIG. 9

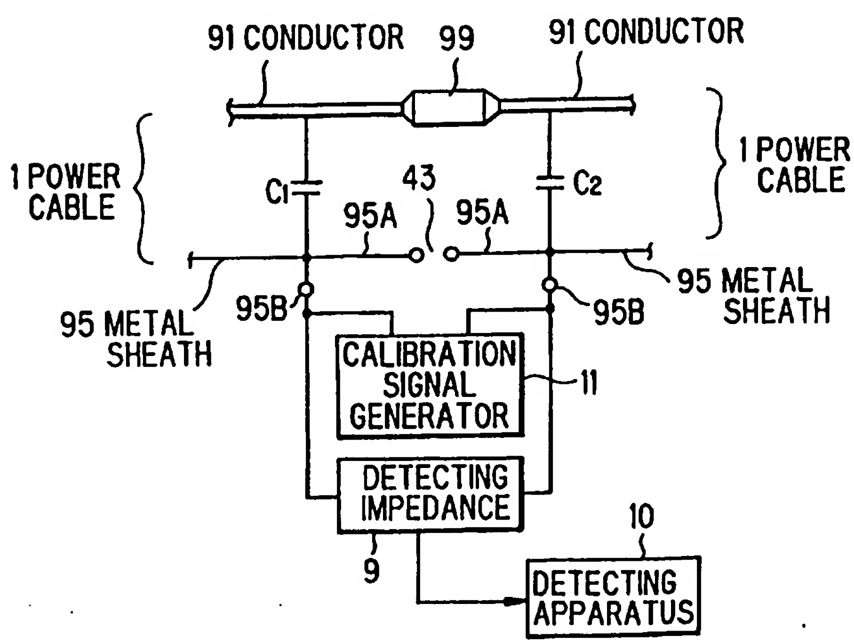

91 CONDUCTOR
99
91 CONDUCTOR
1 POWER CABLE
1 POWER CABLE
C1
43
C2
95A
95A
95 METAL SHEATH
95B
95B
95 METAL SHEATH
CALIBRATION SIGNAL GENERATOR
11
DETECTING IMPEDANCE
10
9
DETECTING APPARATUS

FIG. 10A

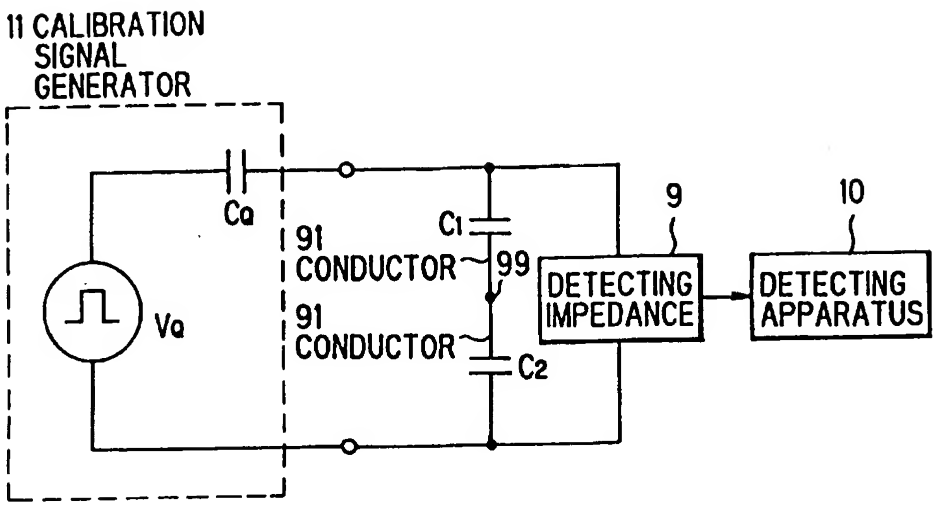


FIG. 10B

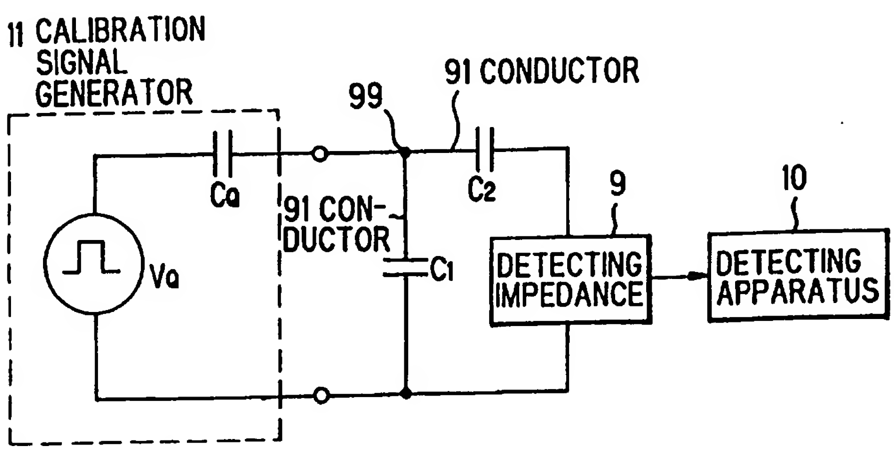


FIG. 11

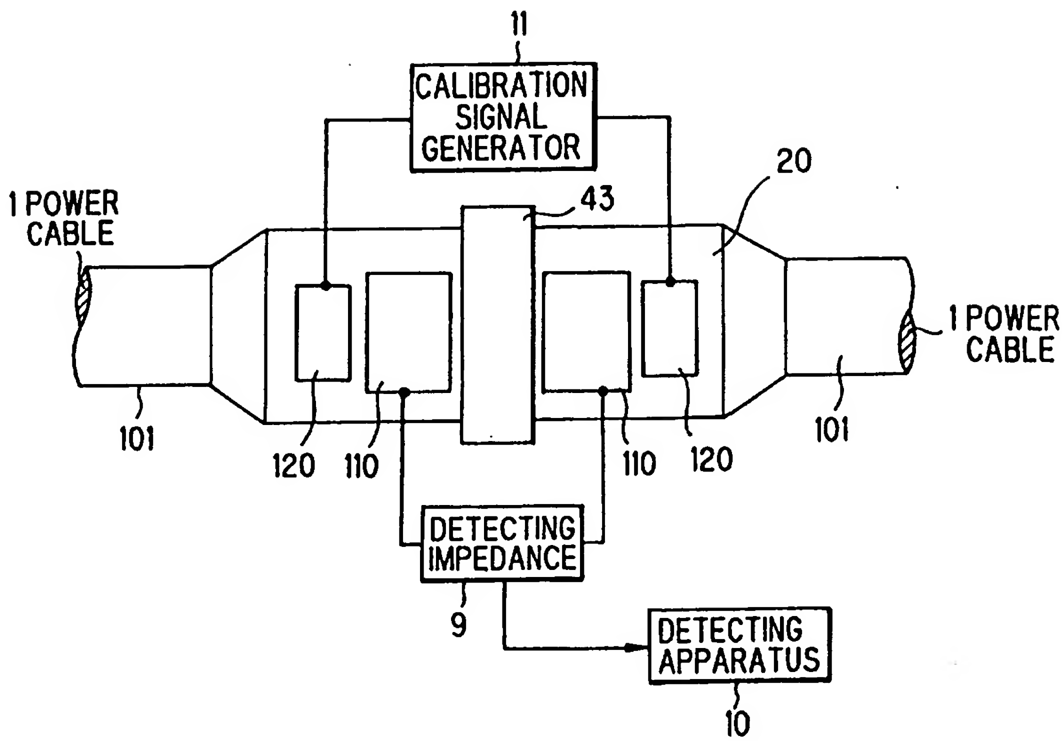

11
CALIBRATION SIGNAL GENERATOR
20
43
1 POWER CABLE
1 POWER CABLE
101
120
110
110
120
101
DETECTING IMPEDANCE
9
DETECTING APPARATUS
10

FIG. 12

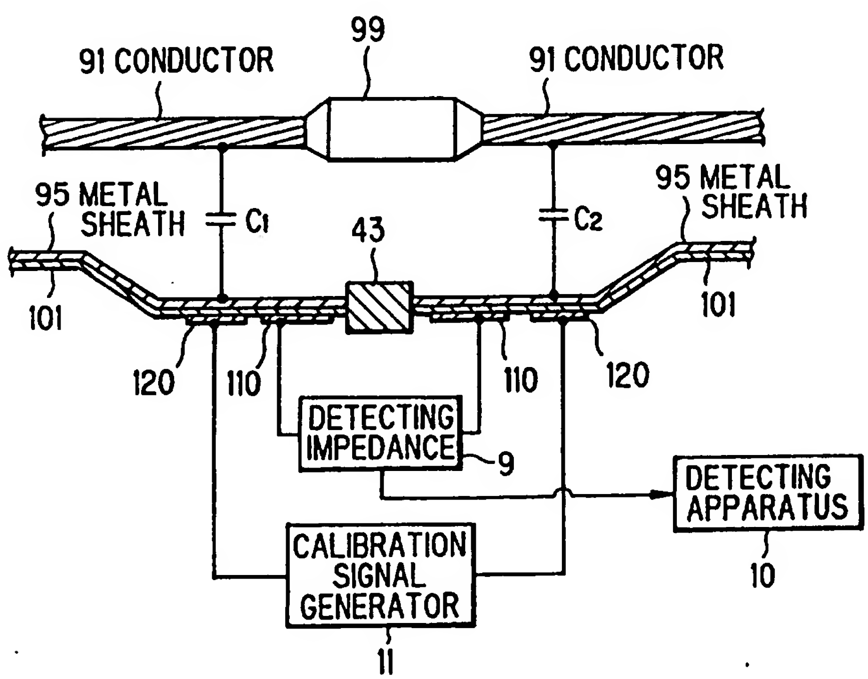
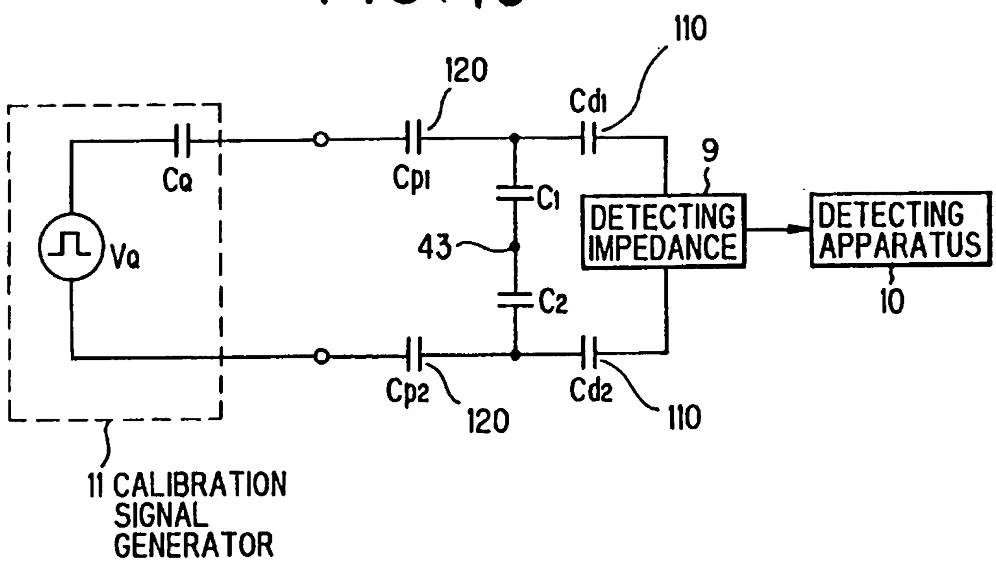

99
91 CONDUCTOR
91 CONDUCTOR
95 METAL SHEATH
C1
C2
95 METAL SHEATH
43
101
101
120
110
110
120
DETECTING IMPEDANCE
9
DETECTING APPARATUS
10
CALIBRATION SIGNAL GENERATOR
11

FIG.13


120
110
Cd1
9
Ca
Cp1
C1
DETECTING
IMPEDANCE
DETECTING
APPARATUS
Va
43
C2
10
Cp2
Cd2
120
110
11 CALIBRATION
SIGNAL
GENERATOR